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APPLICATION OF ADVANCED DISPLAYS AND INTELLIGENT INTERFACES TECHNOLOGY

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This report documents the results of an Air Force Research Laboratory in-house program entitled "Advanced Displays and Intelligent Interfaces (ADII)". Specifically, it details how the technology that was developed and integrated within the ADII program was applied to showcase how it could be used in military and commercial environments. The two main capabilities within the ADII program that are addressed are the interactive datawall and the virtual worlds environment. Specific applications, as well as future plans for both capabilities, are discussed.

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0 Report Organization

This final report documents investigations that were conducted by the Advanced Displays and Intelligent Interfaces (ADII) in-house program. Specifically, it addresses the application of the technologies that were developed and integrated within the ADII program to potential military command and control as well as commercial uses. The time period covered by this report is from 1 Oct 1997 to 31 May 1999.

Section1 discusses the background of the ADII program and the command and control requirements being addressed within the program.

Section 2 discusses the composition of the ADII in-house laboratory. The two primary components that are discussed are the developmental Interactive DataWall (ID/W) and the Virtual Worlds three-dimensional environment.

Section 3 discusses the different uses that the ID/W technologies have been experimented with and demonstrated. These include what has been done with the technologies to date and plans for the future.

Section 4 discusses the ways in which the Virtual Worlds technologies have been utilized to showcase their potential military and commercial uses. These include what has been done with the technologies to date and plans for the future.

SECTION 1 ADVANCED DISPLAYS AND INTELLIGENT INTERFACES

The objective of the ADII in-house program is to investigate, develop, evaluate, integrate, demonstrate, and transition evolving high resolution display and human-computer interface technologies that have potential applicability to Air Force command and control operational environments. These include both two and three dimensional displays and interfaces. Emphasis is placed on applying available commercial off the shelf (COTS) technology. In areas where a requirement exists but no COTS solution is either available or imminent, the ADII program has selectively researched potential solutions.

The ADII program is supported by a laboratory that has two main components, the developmental Interactive DataWall and the Virtual Worlds three-dimension environment. These will be explained in detail in the following section. These facilities have been developed by a combination of contractual and in-house activities. Physically, they are located within the Command and Control Technology Center at the Rome Research Site of the Information Directorate of the Air Force Research Laboratory.

The focus of the ID/W research has been on how it could be applied in a typical command center. The basic problem being addressed is that as information technology has invaded the commander's staff, the commander now has to fuse bits of information that are resident on the individual computer screens of his staff into some kind of overall situation awareness within his mind. The concept of the Interactive DataWall is that of a central capability that allows multiple applications to be visible, and available for interaction, so the commander and his staff can evaluate the situation more efficiently, review information faster, and interact with the applications/data/information in as intuitive a manner as possible. This presents the commander and his staff with an excellent medium in which they can collaborate among themselves and also collaborate externally with other command nodes.

The focus of the Virtual Worlds research has been more on developing the actual three-dimensional environment and less on the use of that environment in the command and control operational setting. There has been limited use of the environment, as will be detailed in a later section, for collaboration and quasi-operational type demonstrations and experiments. The emphasis in the near future will be on investigating the potential uses of the Virtual Worlds environment.

To date, the emphasis of most of the reports and papers written on the work done within the ADII program has concentrated on the technology involved. These papers and reports have detailed both the in-house development and integration activities as well as the contractual tasks that have fed the in-house ADII laboratory. This report will concentrate on the end application of the technology that has been integrated within the ADII laboratory to produce a capability a commander, his staff, or commercial enterprises could utilize.

SECTION 2 ADVANCED DISPLAYS AND INTELLIGENT INTERFACES LABORATORY

The ADII laboratory consists of two main entities, the developmental Interactive DataWall and the three-dimensional Virtual Worlds environment.

Developmental Interactive DataWall (ID/W)

This portion of the ADII laboratory, pictured below in figure 1, has been under development since the early 1990s. Commercial off the shelf technology has been combined with specialized software/hardware developed in-house to provide a unique capability for multimedia data display and control. The system features speaker independent voice activation and a wireless pointing device using a video camera-tracked laser pointer. This pointing system offers both conventional computer mouse functionality and electronic grease pencil capability to interact with a high resolution display. The ID/W display consists of 3 video projectors tiled horizontally for a combined resolution of 4800 x 1200 pixels across a 12 ft. x 3 ft. physical screen area.

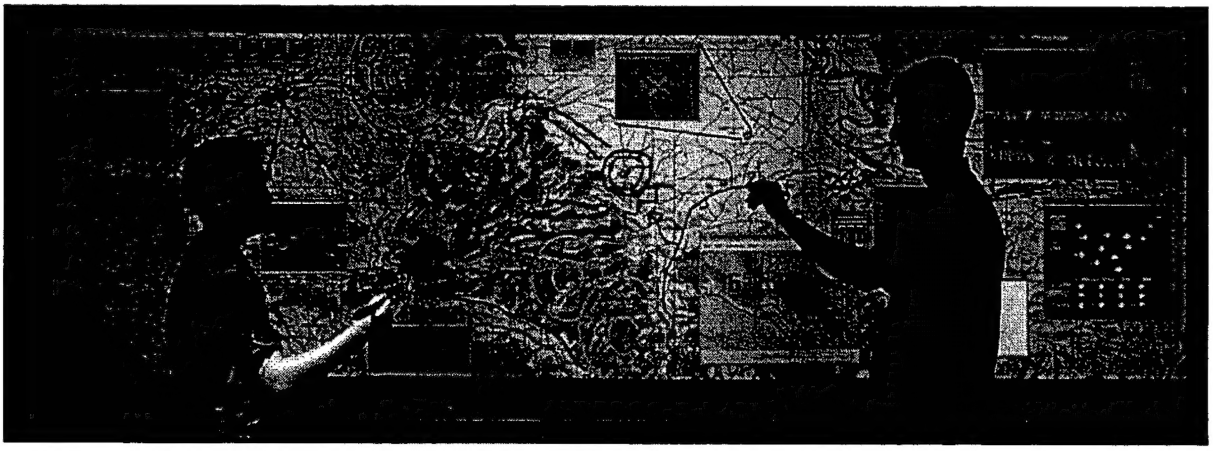

Figure 1. Developmental Interactive DataWall

BBN's HARK continuous speech recognition system provides the speaker independent interface capability. The specific grammar set necessary to interact with both the free-hand and canned drawing modes that are resident on the ID/W was implemented by in-house personnel. This capability allows the ID/W operator to draw in free-hand mode using a standard laser pointer and to draw preset geometric shapes and lines by a combination of voice and laser pointer interaction. The width of these items drawn under either mode can also be varied from thin (one pixel wide) to thick (4 pixels wide) by voice command. Typically, the ID/W operator wears a wireless microphone to utilize the HARK system and activates HARK by speaking a wake up command.

The laser pointer controlled mouse function on the ID/W, which replaces the need for a standard desktop mouse, was implemented by in-house personnel. Each of the three BARCO projectors has a video camera attached to it that has only one function. That is to watch for a red dot on its projector's image. Complimentary hardware/software analyzes this information and provides an input to the operating system of the SGI Onyx computer that provides the BARCO images for the ID/W. The Onyx is tricked into believing that the cursor location information is coming from the standard desktop mouse. Therefore, the laser pointer can be used to do any function the standard desktop mouse can be used to accomplish. The hardware and software used to do the analysis of the red dot on the screen into information the Onyx operating system can use as a substitute for the desktop mouse was designed and developed by in-house personnel.

As has been mentioned already, the computing engine for the ID/W is an SGI Onyx workstation with three reality engines, each feeding one of the three BARCO projectors.

The tiling of the individual projector outputs into a single continuous display and interaction environment is accomplished through the use of X-Software's X-META-X commercial software application. It produces a single window manager environment out of the three individual window managers. This allows for images and windows to be placed anywhere across the 12' by 3' screen without appearing to be fragmented by the transition from one projector's image to the next. It appears as though one projector is producing the image that is shown. One of the fundamental problems that was overcome in order to be able to show these multi-projector images without the gaps and discontinuities typical in many tiled systems was the precise system alignment required. This was accomplished by an in-house developed series of alignment patterns and procedures. Typically, projectors have their own internally generated alignment patterns. These are used to tune the outputs of separate projectors. They only deal with the actual projector performance, not the performance or alignment of the whole system from the computing platform that is generating the image all the way through the projector. The in-house developed capability uses the Onyx workstation to generate the alignment patterns used to align the projectors. This in essence tunes the performance of the whole system from the Onyx through the projectors ensuring that the images across the three projectors are properly aligned.

The ID/W also has the capability to display either recorded or live video. Recorded video can be stored as JPEG clips and replayed by the SGI Onyx whenever the operator desires. A device called the Super View 1000 enables real-time satellite feeds to be shown on the ID/W. This device, however, allows the video to be overlaid onto the screen without using any computation power of the SGI Onyx, except for controlling the windows that the videos appear within. The Super View 1000 allows four separate videos to be shown simultaneously.

Any X-compliant application with a Graphical User Interface (i.e. desktop mouse controlled application) is a candidate for porting into the ID/W system for display/interaction.

Three-dimensional Virtual Worlds (VW) Environment

The Virtual Worlds (VW) environment has been under development since the early 1990's and it consists of a large screen stereoscopic projection system. Various multi-modal input devices have been integrated into this system to allow the operator to interact with the virtual objects being displayed. The large screen stereoscopic projection system, consisting of left and right eye imagery overlaid across the same screen area via a dual projection system having an upper capacity of 4 million pixels per projector (1024 X 768 pixels are actually being displayed), supports stereoscopic imagery for non-immersive virtual worlds applications. Using filters, the system polarizes the left and right eye images at opposing angles. The images are separated by polarized glasses worn by the user/observers, thereby creating the illusion of depth. The Virtual Worlds Environment user can interact with the environment objects via any of a number of interface devices such as a data glove, 3-D mouse, Magellan, speech recognition, and spaceball.

The speech recognition system used is the same HARK continuous speech recognition application used by the ID/W. The grammar set developed for the VW system allows the operator to accomplish many of the same functions that can be done using the data glove such as selecting items from the pull-down menus, opening and closing scenes, and creating and deleting objects within scenes.

The main environment software is called Cubeworld and was developed for use in the ADII laboratory under contract by Mitre, Burlington, MA. The basic capability has been enhanced by a combination of in-house and summer faculty tasks.

An application called the Designer's Workbench is used to create new and modify existing models of objects. These objects are then imported into the Cubeworld environment for viewing and manipulation. A feature called texture mapping allows digital images of surfaces such as brick, wood, concrete, etc. to be put onto the surfaces of objects to give them a very realistic appearance of these materials. This allows a user to take a digital photograph of a desired material and then import it into the Designer's Workbench for use on any objects of interest.

SECTION 3 INTERACTIVE DATAWALL APPLICATIONS AND DEMONSTRATIONS

The Interactive DataWall (ID/W) and its associated technologies have been the subject of many demonstrations. In addition, it has also been the basis for a number of command and control related implementations/demonstrations/experiments/exercises. The list of these include:

1) ID/W technology demonstrations
2) High-level visitor technology demonstration focal point
3) Joint Force Air Component Commander (JFACC) Test-bed
4) Deployable Re-configurable Command Center
5) SBIR demonstration mechanism
6) Army Mountain Peak 98-1 exercise

Future activity plans for the ID/W include:

1) PC-based Interactive DataWall
2) an inter-building transportable Interactive DataWall
3) USTRANSCOM Advanced Concept Technology Demonstration (ACTD)
4) Visualization of Battlefield Energy (ViBE)
5) ID/W technology enhancements.

ID/W TECHNOLOGY DEMONSTRATIONS

The ID/W capability is a popular agenda item whenever visitors to the Information Directorate of the Air Force Research Laboratory are given technology demonstrations. During calendar year 1998, approximately 83 individual demonstrations of the ID/W were given, all by the in-house personnel that work with and on the associated technology. The audiences varied from General-level military officers to some local second grade students on a field trip. Most visitors represented government organizations. All of the services as well as other government offices including senators and house members have also been among the demonstration recipients.

HIGH-LEVEL VISITOR TECHNOLOGY DEMONSTRATION FOCAL POINT

In addition to demonstrations of the ID/W technology itself, the ID/W was used as the display/interaction capability for numerous demonstrations for high-level visitors. Typically, the agenda constructed for the visitors would include numerous technical programs being conducted at the Information Directorate. Representative programs on these agendas include Video Mosaic, Force Level Execution (FLEX), and Joint Assistant for Deployment and Execution (JADE). Video Mosaic is an effort that stitches together individual scenes from either still photographs or video camera frames into a continuous panoramic scene of an area of interest. Typically shown on a SUN workstation with a 19' screen, Video Mosaic is an application that benefits greatly from the greatly expanded display area of the ID/W. FLEX is an air battle plan execution monitoring tool

intended for use by the Combat Operations Division of an Air Operations Center. It requires the operator to use multiple windows concurrently to properly monitor the status of an executing Air Tasking Order. Again, the physical space on the ID/W is ideal for having multiple windows open and visible simultaneously. It also allows the FLEX operator to interact with these windows via the laser pointer for faster operation than with a desk top mouse. JADE is a planning tool being developed for USTRANSCOM for use in planning the movement of supplies/equipment/personnel/etc. It is operated by means of dragging and dropping items on multiple screens which again makes the ID/W an ideal environment in which to employ it.

Among the visitors that the ID/W has been used as the display/interaction medium for are: Dr. Hastings (USAF/CD), the Air Force Scientific Advisory Board, Senator Charles Schumer, Congressman Sherwood Boehrlert, Lt. Gen. MacDonald (NORAD/CV), Dr. Helwig (SAF/AQR), Col. Simpson (USCENTCOM), and Congressional Staffers.

JOINT FORCE AIR COMPONENT COMMANDER (JFACC) AFTER-NEXT TEST-BED

A second ID/W was developed and installed to form the core of the JFACC test-bed. The JFACC After-Next program is a DARPA sponsored effort that the Information Directorate is participating in. This program is researching how the next generation Air Operations Center might do its air campaign planning mission in a just in time mode as opposed to the rigidly structured mode it is presently done in. This ID/W is SUN workstation based, where the development ID/W is SGI based. The decision to have the SUN platform as the basis for this implementation was made because the SUN workstation is the de facto standard within the Air Force for computing platforms. This ID/W is part of the JFACC After-Next network that at one point had nodes at the Command and Control Battle Lab, Logicon, and DARPA in addition to the one at the Information Directorate. All of the functionality implemented on the developmental ID/W has been replicated on this ID/W. This was the first program to actually use the ID/W as part of its command and control pseudo-environment. There is also network connectivity between the two ID/Ws within the Information Directorate (the developmental ID/W and the JFACC ID/W) which enabled experiments on collaborating ID/Ws.

DEPLOYABLE RE-CONFIGURABLE COMMAND CENTER (DRCC)

The DRCC is part of the Configurable Aerospace Command and Control program. This program is developing technology required to enable future responses to world-wide contingencies to deploy with the minimum footprint necessary to carry out their mission. The DRCC is the first piece of this future deployable capability to be implemented. It houses a smaller version of the ID/W. The screen size is 9' x 2 1/4 ' (versus 12' x 3' for the development ID/W) and it is housed within an Air Force Expandable S-530 A/G Shelter. This shelter is 12' x 7' x 7.2' and, when combined with a second S-530 shelter, expands to three times the volume of a single S-530. The shelter is self-contained with its own motor-generator set for all its required power and an environmental unit that

provided air conditioning to ensure adequate cooling for the electronic equipment. Functionally, it has all of the features of the developmental ID/W and is periodically upgraded to transition the latest improvements that have been implemented in the developmental environment. As will be detailed in the next section, the Virtual Worlds environment was employed in the design stage for this capability.

SMALL BUSINESS INNOVATIVE RESEARCH DEMONSTRATION

In October 1998, the ID/W was used as the display and manipulation media for the final demonstration of a small business innovative research contract entitled "Global Awareness Virtual Test-Bed". The demonstration utilized the large display space and wireless interaction capability of the ID/W to simultaneously show and manipulate multiple windows generated by a number of separate applications. The objective of the demonstration was to show how, given the capability to present the commander with information from separate real-time applications on one display, he could mentally fuse and correlate all of this information into a viable situational awareness picture.

ARMY MOUNTAIN PEAK 98-1 EXERCISE

In August 1998, the Deployable Re-configurable Command Center (DRCC) was sent to Fort Drum, NY to participate in the Army's Mountain Peak 98-1 exercise. This was a joint exercise involving Army/Navy/Air Force participants. The Army's 10th Mountain Division used the DRCC to display and manipulate real-time multi-media data to provide situational awareness information to the Division Commander and his battle staff. Physically, the DRCC was connected to the Division main and its local information network. The commanding general was using the DRCC to conduct his daily morning briefing by the end of the exercise. The DRCC got such great comments on its use during the exercise that the 10th Mountain Division requested that it participate in another exercise scheduled for December 1998 and be considered for their deployment to Bosnia in July 1999.

FUTURE ID/W PLANS

PC-BASED INTERACTIVE DATAWALL

A pc-based Interactive DataWall is being developed for use in environments not compatible with either of the previously developed versions (Silicon Graphics and SUN). The cost of this implementation is estimated to be $100K for all required hardware and software. It will have all of the features of the other implementations including voice and laser pointer interaction. Most of the hardware and software for this implementation has been procured and the first prototype is expected to be completed by mid FY-00.

INTER-BUILDING TRANSPORTABLE INTERACTIVE DATAWALL

Another version of an ID/W being developed will take the form of a rolling container that can be wheeled through a standard office doorway. It will then unfold into a three panel

display with embedded projectors that can be set up and aligned within an hour for rapid relocation and use within a single building. The design for this capability is presently in the formative stages and is expected to be prototyped by the end of FY-00.

USTRANSCOM ADVANCED CONCEPT TECHNOLOGY DEMONSTRATION (ACTD)

The USTRANSCOM/J5 is in the process of proposing an ACTD to the office of the Secretary of Defense's Advanced Systems and Concepts office (OSD/ASC). An interactive DataWall is an integral component of this ACTD. It would be used as the primary display and manipulation mechanism within the USTRANSCOM's Mobility Control Center (MCC). Starting in FY-00 and ending in FY-03, this ACTD would deliver to the MCC in FY-03 an Interactive DataWall with supporting decision support tools that would enable the operators in the MCC to display a transportation-based common operational picture (COP) with the ability to drill down as deep as necessary into the data/information used to construct this COP.

VISUALIZATION OF BATTLEFIELD ENERGY (ViBE)

This activity is a contract that has been awarded to Sterling Software. It will develop models that are capable of portraying graphically the military potential possessed by enemy forces/assets that have been detected on a battlefield. The ID/W will be the primary display and manipulation mechanism for this effort's demonstration. It will be the first application developed outside of AFRL/IF specifically with the ID/W intended as the end host system.

ID/W TECHNOLOGY ENHANCEMENTS

In addition to the above detailed future plans, the technology behind the ID/W is continually being updated. Specific planned future enhancements include replacing the present limited voice interaction system with a capability that won't require the development of grammar sets, replacement of the present cathode ray tube (CRT) based display projectors with liquid crystal display (LCD) projectors when their resolution approaches that of the present CRT projectors, multiple simultaneous user capability, and 3-D audio that will allow for multiple outputs to different groups of users.

SECTION 4 VIRTUAL WORLDS APPLICATIONS AND DEMONSTRATIONS

The Virtual Worlds environment and its associated technologies have been the subject of many demonstrations. In addition, it has also been used in a number of applications within the Advanced Concepts and Applications Branch with the Information Directorate. The list of these include:

1) Virtual Worlds environment technology demonstrations
2) design and development of the Deployable Re-configurable Command Center
3) rendering of the proposed Information Directorate building consolidation
4) 3-D collaboration research.

Future activity plans for the Virtual Worlds environment include:

1) joint programs with Space Vehicles Directorate
2) joint modeling and simulation programs
3) update proposed Information Directorate building
4) Virtual Worlds technology enhancements.

VIRTUAL WORLDS ENVIRONMENT TECHNOLOGY DEMONSTRATIONS

The Virtual Worlds capability is a popular agenda item whenever visitors to the Information Directorate of the Air Force Research Laboratory are given technology demonstrations. During calendar year 1998, approximately 43 individual demonstrations of the Virtual Worlds environment were given, all by the in-house personnel that work with and on the associated technology. The audiences varied from General-level military officers to some local second grade students on a field trip. Most visitors represented government organizations. All of the services as well as other government offices including senators and house members have also been among the demonstration recipients. Many of the same individuals named above for the ID/W demonstrations were also presented demonstrations of the Virtual Worlds environment.

DEPLOYABLE RE-CONFIGURABLE COMMAND CENTER DESIGN AND DEVELOPMENT

During the design and development of the DRCC, a tool called the Designer's Workbench was employed to model potential hardware configurations of the DRCC. After modeling the options, the models were ported to the Virtual Worlds environment for viewing and manipulation. This allowed the designers and developers to view and modify the DRCC configuration without having to physically relocate components. This was one of the reasons that the DRCC was successfully constructed within a very short (3 months) period of time.

INFORMATION DIRECTORATE BUILDING CONSOLIDATION RENDERING

The Designer's Workbench was also used to model the proposed building configuration of the Information Directorate consolidation into a single building. Starting with the consolidated building blueprints, a model was constructed of the building exterior and surrounding grounds. The inside of the entrance lobby was also modeled. The models were then imported into the Virtual Worlds environment for viewing. These models could be used by AFRL/IF as well as contractors when implementing the building consolidation and actual design tradeoff options have to be analyzed and chosen.

3-D COLLABORATION RESEARCH

Working with the Mitre Corporation of Bedford, MA, AFRL/IF is researching how collaboration between multiple sites can be implemented and utilized in a three dimensional environment. Issues being addressed are how one location can be made aware of the image being used at other locations, how effective three dimensions can be used, and what bandwidth of communications is required to support this collaboration.

FUTURE VIRTUAL WORLDS PLANS

SPACE VEHICLES DIRECTORATE JOINT PROGRAMS

A number of activities are underway and in the planning stages that could produce joint programs with the Space Vehicles Directorate of the Air Force Research Laboratory. Among these activities are cooperative proposals being submitted to NASA for funding, membership on the space-related Technical Planning Integrated Program Team (TPIPT), and importing space vehicles models provided by the Space Vehicles Directorate into the Virtual Worlds environment. Any one of these activities could lead to a significant amount of research and development being initiated in the space technology field.

MODELING AND SIMULATION PROGRAMS

Another area being investigated for potential research and development activity is that of modeling and simulation. Stated above was one instance of using the Interactive DataWall as a medium for displaying and interacting with a developed simulation capability. The Virtual Worlds environment holds a much larger potential as a medium to develop, demonstrate, and employ modeling and simulation technology. Branches within the Information Directorate, located at both Rome and Dayton, are interested in pursuing this use of the Virtual Worlds environment.

UPDATE PROPOSED INFORMATION DIRECTORATE BUILDING

Since the original modeling of the proposed consolidated Information Directorate building was done using the Designer's Workbench, the blueprints have been modified. Therefore, the models need to be updated to reflect these changes.

VIRTUAL WORLDS TECHNOLOGY ENHANCEMENTS

The technology that supports the Virtual Worlds environment is continually being improved, especially in the commercial marketplace. The intent is to install this technology as requirements dictate and funding allows as well as to develop other required capabilities in-house that are not being addressed in the commercial world. Included in these are the ability to view other collaborative participants' viewpoints in window inserts, automatically invoking varying levels of model abstractions based on viewing level of a scene (i.e. closer to objects the view the more detailed the models and the farther away from objects the less detailed the models), and investigation and installation of a more robust voice interaction system.

MISSION OF AFRL/INFORMATION DIRECTORATE (IF)

The advancement and application of information systems science and technology for aerospace command and control and its transition to air, space, and ground systems to meet customer needs in the areas of Global Awareness, Dynamic Planning and Execution, and Global Information Exchange is the focus of this AFRL organization. The directorate's areas of investigation include a broad spectrum of information and fusion, communication, collaborative environment and modeling and simulation, defensive information warfare, and intelligent information systems technologies.